Electro-optic Identification Research Program: Automatic Target Recognition/Computer Aided Identification Task

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LONG TERM GOALS

The overall goal of the Electro-Optic Identification (EOID) Research Program is to support the performance of EOID sensors transitioning to the fleet. EOID is used in the identification of Mine Like Objects (MLOs) and is a pressing need for Mine Countermeasures (MCM) operations. The EOID sensors include the Streak Tube Imaging LIDAR (STIL), which is transitioning to the AN/AQS-20A and the WLD-1 (Remote Mine-hunting System) programs, and the Laser Line Scan (LLS), which has been delivered to the Fleet in the form of the AN/AQS-14A(V1) program. Through these transitions, EOID will be a key element in implementation of Fleet plans for a robust organic MCM capability. The EOID Research Program will begin to provide the tools to meet specific Fleet needs and capabilities, which include:

- Perform mission planning, real-time performance assessment, and post-mission analysis
- Flow down Fleet identification requirements to the system and operational parameters
- Develop Computer Aided Identification (CAI) algorithms to aid in the operator identification of mines
- Develop Autonomous identification capability for future systems
- Assess and evaluate alternate designs for future systems

OBJECTIVE

The overarching objectives of the program are to validate existing performance prediction and simulation models and to develop and test Automatic Target Recognition Algorithms (ATR) for electro-optic identification (EOID) systems. The major objective of the ATR/CAI task is to apply baseline detection/classification algorithms to FY01 field test data and to convert these detection algorithms into the EOID browser for computer aided identification capabilities.

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14. ABSTRACT

The overall goal of the Electro-Optic Identification (EOID) Research Program is to support the performance of EOID sensors transitioning to the fleet. EOID is used in the identification of Mine Like Objects (MLOs) and is a pressing need for Mine Countermeasures (MCM) operations. The EOID sensors include the Streak Tube Imaging LIDAR (STIL), which is transitioning to the AN/AQS-20A and the WLD-1 (Remote Mine-hunting System) programs, and the Laser Line Scan (LLS), which has been delivered to the Fleet in the form of the AN/AQS-14A(V1) program.

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APPROACH

The approach to object detection in this effort is based on a local spatial shape-filtered background anomaly scheme. This scheme uses least squares error (LSE) strips to search for background anomalies of certain specified size and shape that stick out from the local background. Once an object has been detected, it is segmented using a two-dimensional (2-D) LSE fit on the local background, sufficiently away from the object centroid, to separate object pixels from background pixels. The object perimeter boundary pixels are then enumerated using customized morphological operations, leading to computation of basic geometric features (object centroid, length, width, area, and orientation).

Dr. Mahmood Azimi at Colorado State University has been funded to develop a classification scheme based on Zernike moments and neural networks. This classifier will use the CSS detection outputs to generate Zernike moment based features that will be utilized in a nearest neighbor neural network for final classification.

The data analysis/browsing tool developed under this task is a graphical user interface (GUI) modification of a previous keyboard based analysis/browsing tool developed under the FY00 Coastal Benthic Optical Properties (CoBOP) program. The modified GUI analysis/browser tool was developed for quick and easy browsing of data from all three of the EOID sensors used in the research program and was programmed in interactive data language (IDL) software. This tool is being developed to be used for field test support and to support ATR/CAI development.

WORK COMPLETED

The object detection routine was applied to the FY01 field test data, both STIL and LLS, for preliminary detection results. For STIL, the detection routine was also applied to the range imagery for beginning efforts in fusing contrast and range information for enhanced detection capabilities. In support of this, the rendering technique for the range map was modified for significantly improved resolution with reduced "contrast leakage".

The EOID GUI analysis/browser tool was completed. This includes the incorporation of on-the-fly 3-D display of STIL data (see Figure 1) and quick and easy ground truth capabilities. Efforts to convert the object detection routine into the EOID browser for computer aided identification were begun, but not completed.

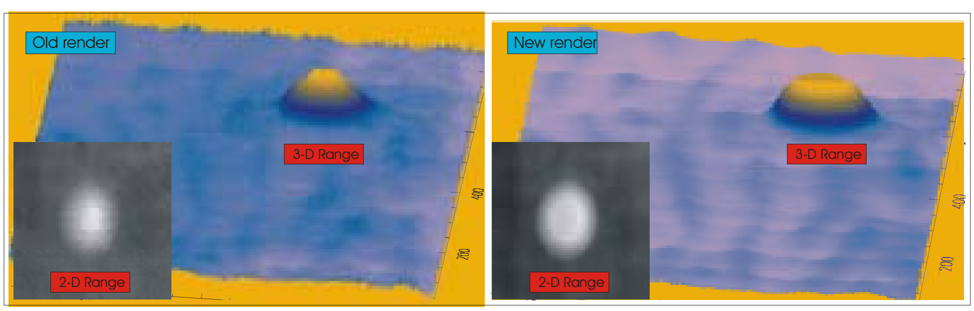

Figure 1. Comparison of the old range rendering technique (left) versus the new range rendering technique (right) shows significant improvement in range resolution.

The target identification task computed results using the FY01 field test data and focused research towards development of robust segmentation and shape-dependent feature extraction. The GVF Snake method is being developed and fine-tuned because of its capability to segment low contrast objects whose edges are missing or indistinguishable from the local background.

RESULTS

The incorporation of the on-the-fly 3-D display in the EOID browser, coupled with the improved range resolution significantly increased computer aided identification capabilities in a post-mission environment (Figure 2).

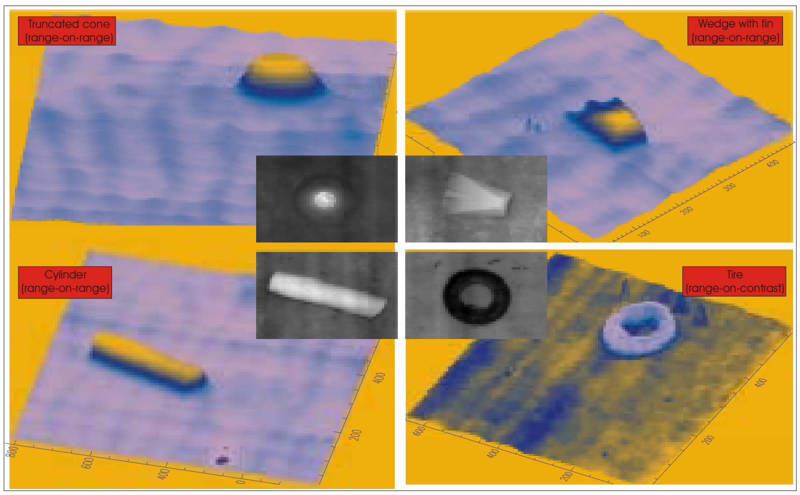

Figure 2. Shape examples of the EOID browser 3-D on-the-fly displays along with corresponding 2-D contrast images (inset). [Three dimensional shapes of truncated cone (upper left corner), trapezoid with fins (upper right corner), cylinder (lower left), and tire with fish (lower right)]

The background anomaly detection algorithm was applied to the STIL and LLS data (Figures 3-5) showing good results. These results are from a single executable and are therefore fully automated. Application of the detection algorithm to the STIL range data showed that not only is the range information an invaluable supplement to the contrast data, but that due to its invariance to low contrast and non-uniform targets (relative to contrast), it may actually be the more powerful channel for mine identification than the corresponding contrast imagery. Results from the range imagery showed excellent performance.

The target identification effort showed some very promising results by using a combination of field test data and synthetic data, where synthetic data was used to fill insufficient data samples from the field test. Table 1 shows these results, where type 1 is man-made non-target panels, type 2 is man-made circular shaped non-targets, type 3 is circular shaped targets, type 4 is trapezoidal-shaped targets, and type 5 is bullet-shaped targets.

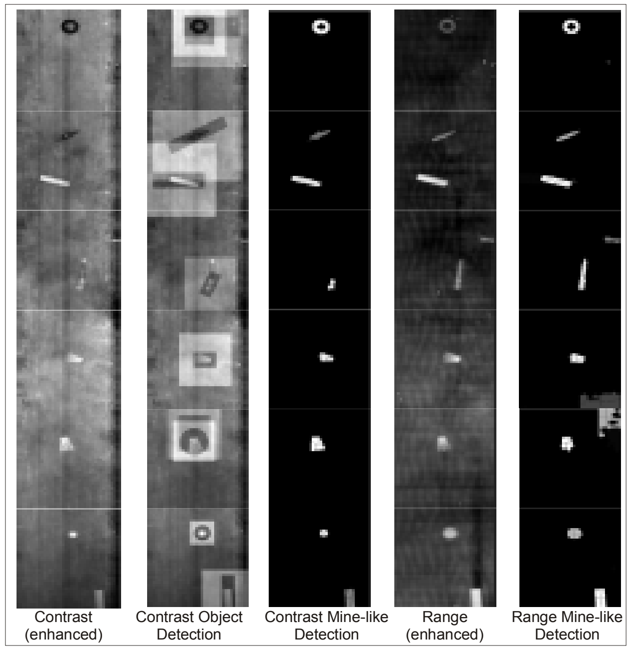

Figure 3. Mine-like detection results for STIL data [run 15AUG2001-004821.BIN]. Notice that the range data is more invariant to low contrast and non-uniform effects than the contrast data, yielding better results than the corresponding contrast data. These results are from a single executable and are therefore fully automated. [Sample data run through target field containing truncated cones, cylinders and trapezoids. Sample enhancement, detection, and segmentation]

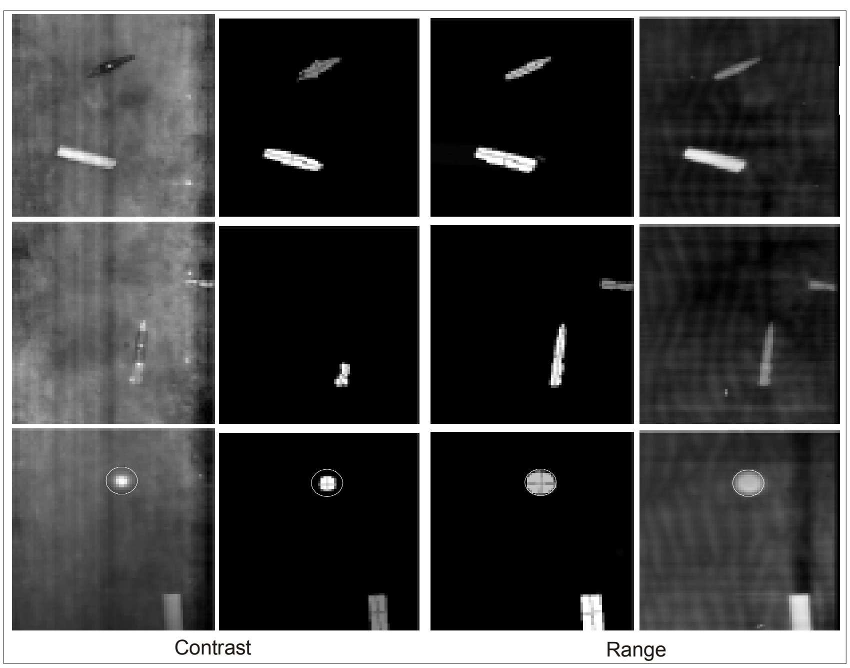

Figure 4. Closer inspection of the low contrast targets (top and bottom rows) and the non-uniform targets (middle row) show significant advantages for the range data over the corresponding contrast data. Results from the range data showed excellent performance. [Zoomed sample data run through target field containing truncated cones, cylinders and trapezoids. Sample enhancement, detection, and segmentation]

TABLE 1: Confusion matrix of the three-layer network

	Type 1	Type 2	Type 3	Type 4	Type 5
Type 1	88%		8%		4%
Type 2		96%	4%		
Type 3	8%		92%		
Type 4				100%	
Type 5	4%				96%

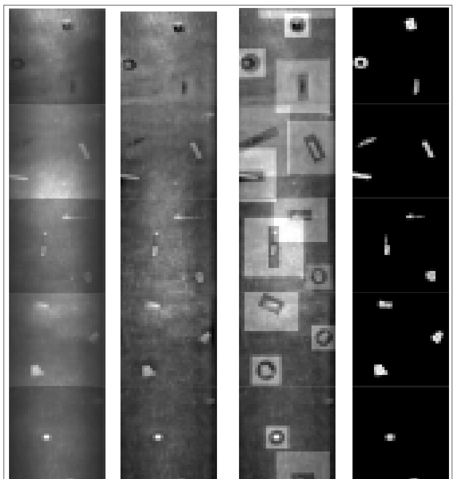

Figure 5. Mine-like detection results for R-LLS data [run EOID-2001-08-14-20-50-17.RAW]. The contrast data showed difficulty segmenting low contrast and non-uniform targets. These results are from a single executable and are therefore fully automated. [Sample data run through target field containing truncated cones, cylinders and trapezoids. Sample enhancement, detection, and segmentation]

IMPACT/APPLICATIONS

The long-term results obtained by this project are expected to support the current transitions of EOID to the fleet, and to lay a firm foundation for the development of next generation AEOID sensors designed for next generation organic platforms.

The basic CAD/CAC building blocks of the ONR EOID effort can be used on both the AN/AQS-14A(V1) and AN/AQS-20A programs either in Post Mission Analysis (PMA) or on the aircraft. The successful use of range data in ATR shows the benefit of having 3D imaging for EOID. Improvements in detection and classification of low contrast objects are of critical importance to the Navy especially for bio-fouled targets.

The improvement in range imaging will make the display of range imagery much easier and provide the operator with better information in order to make an identification call.

TRANSITIONS

The techniques used in processing the range information can be used in the AN/AQS-20A PMA software in FY03. The final step of taking the segmented mine-like object and helping the operator make an identification call will have to be researched by the AN/AQS-20A project. The improvements in the rendering algorithm are dramatic and will be incorporated in the AN/AQS-20A towed body during the next software update.

RELATED PROJECTS

The detection routine developed under this task was leveraged from the CSS FY01 independent laboratory in-house (ILIR) research project *Underwater Electro-optic Image Processing Task*. In addition, data collected here is being made available to the Program Executive Office for Mine and Undersea Warfare (PEO(MUW)) for their use in system development.

PUBLICATIONS

"An Algorithm for Detection of Mine-like Objects Using Streak Tube Imaging Lidar Data", Andrew Nevis Et Al*, Ocean Optics XVI*, Santa Fe, New Mexico, November 2002

"A Baseline Detection Algorithm using Background Anomalies for Electro-optic Identification Sensors", Andrew Nevis Et Al, *Oceans 2002 IEEE Conference*, Biloxi, MS, October 2002

"Underwater Target Identification using GVF Snake and Zernike Moments", Guohzi Toa, Mahmood R. Azimi-Sadjadi, and Andrew Nevis, *Oceans 2002 IEEE Conference*, Biloxi, MS, October 2002

"Object Detection using A Background Anomalies Approach for Electro-optic Identification Sensors", Andrew Nevis Et Al, *Fifth International Symposium on Technology and the Mine Problem*, Monterey, Ca, April 2002